Biological Research and Monitoring Subactivity

Subactivity	FY 2000 Estimate	Uncontrol. & Related Changes	Program Changes[1]	FY 2001 Budget Request	Change from FY 2000
Biological Research and Monitoring	113,232	+1,690	+8,508	123,430	+10,198
Total Requirements $000	113,232	+1,690	+8,508	123,430	+10,198

[1] See Program Change Section for details on programmatic decreases (-$3,992), Decision Support-Resource Management (+$1,200), Columbia River Aquatic Resources (+$2,000), Place-based Studies - Yellowstone (+400), DOI Science Priorities Initiative (+$6,500), Amphibians (+$1,400), Fish and Wildlife Disease (+$1,000).

Current Program Highlights

The Biological Research and Monitoring subactivity generates specialized biological research and monitoring information needed to effectively manage and conserve biological resources. Our Nation's biological resources are an invaluable and increasingly vulnerable part of our country's heritage and economy. These resources are varied, widely distributed, and complex. They extend from the polar bear habitats of the Arctic to the seagrass beds of the Florida coast and encompass the aquatic treasures of the Great Lakes and the beauty and extreme conditions of the Southwest deserts. These resources include isolated islands of incredible diversity such as Hawaii and large interconnected waters like the Mississippi River. The types of habitats that we live alongside include mountains, forests, rangelands, wetlands, coasts, and open waters. The products of these habitats provide us with food, energy, medicine, transportation, and enjoyment. These habitats are vulnerable to the adverse effects of many natural and human-induced changes.

Research is needed to reduce and avoid the costs of controlling and eradicating invasive species. These costs may reach $100 billion annually over the next 50 years. Investigations conducted to evaluate the threats posed by toxic substances can aid in determining the most effective regulations. Studies are required to help contain and eradicate diseases that can devastate regional wildlife populations. Single disease outbreaks have killed 300,000 or more waterfowl and outbreaks resulting in 10,000 or more deaths occur almost every year. Monitoring of environmental conditions and populations is critical to providing the yardstick by which the success of management strategies and resource policies is measured.

Management responsibility for biological resources falls on a number of State and Federal government agencies. The Department of the Interior (DOI) primarily manages Federal lands and biological resources. DOI land and resource management bureaus need the scientific understanding and the technical tools to be able to wisely manage lands and resources on a sustainable basis.

To develop the biologic information needed by land and resource managers, the USGS Biological Research and Monitoring subactivity is organized to include the eight program elements shown in the table below. Grouping science within these program areas provides an opportunity to plan and promote integration and cohesion among individual science projects and allows for periodic evaluations of accomplishments.

The following table displays the Biological Research and Monitoring subactivity funding:

Biological Research and Monitoring Program Areas ($000)

Program	FY 2000 Enacted	FY 2001 Request
Status & Trends	21,746	21,544
Contaminants	10,970	10,821
Fisheries & Aquatic Resources	14,784	15,409
Wildlife	17,070	19,021
Ecosystems	26,528	26,687
Application of Science Information to Management	3,114	4,286
Endangered & At-Risk Species	13,836	13,353
Invasive Species	5,184	5,803
DOI Science Priorities Initiative	N/A	6,500
Total Biological Research & Monitoring	113,232	123,430

Science Information System

The Science Information System (SIS), an automated query system, has been developed to make biological science activities readily available to all interested parties. The SIS is designed to meet the information needs of scientists and resource managers both within the USGS and Department of the Interior and in partner organizations, client agencies, and special interest groups. Its purpose is to provide a comprehensive scientific information database containing summary descriptions of the objectives, location, funding sources, general approach, and anticipated applications of results of USGS scientific efforts. The SIS database includes metadata on projects that contribute to Biological Research and Monitoring program areas. The SIS (which is component of the National Biological Information Infrastructure, or NBII) may be accessed and queried on the world wide web at **http://cristel.nal.usda.gov:8080/star/brd.html**.

The following describes the Biological Research and Monitoring subactivity by program element:

Status and Trends

Biological status and trends science integrates inventory and monitoring efforts and current historical data sets with a focus on DOI trust resources and lands. This program area seeks to provide an integrated monitoring approach that describes and tracks the abundance, distribution, productivity, and health of the Nation's plants, animals, and ecosystems.

It encompasses activities at the landscape, community, population, and genetic levels and develops inventory and monitoring techniques and statistical methods specifically applicable to DOI land and resource management needs. While focused on Department lands, information is also useful to other public and private organizations. Regular assessments and analyses of biological resources help policymakers and the public make informed decisions about their management, while maintaining the health, diversity, and ecological balance of biological resources. The work involves extensive cooperation with Federal, State, and private agencies and organizations.

National Park Monitoring – To deal with natural resource management concerns, a long-term monitoring program evaluates status and trends of representative ecological communities. In national parks in 7 biogeographical regions, USGS scientists assist in the development of the prototype monitoring framework, statistical design and methodology. A goal of the prototype program is to provide high quality methods and tools that can be used in other parks, refuges, or on DOI lands within similar ecological areas.

Bird Monitoring -- Monitoring bird populations is a special emphasis for USGS because of the federal role in conservation of migratory birds. Migratory bird populations surveys provide data for establishing waterfowl hunting regulations and tracking changes in populations of songbirds and seabirds. The USGS maintains the national Bird Banding Laboratory, and the most important bird monitoring database in North America, the Breeding Bird Survey.

Mammal Monitoring -- USGS scientists have partnership efforts to monitor the status and trends of wildlife populations that extend from the Arctic to Yellowstone to the Everglades of Florida. Focal species include polar bears, moose, elk, and manatees.

Amphibian Monitoring – In the face of growing recognition that many species of frogs, toads, and salamanders are experiencing alarming population declines, USGS is stepping up its amphibian monitoring efforts. USGS coordinates the national North American Amphibian Monitoring Program with Federal and State agency partners. (See program change section for more information,)

Fish Monitoring – In cooperation with States, Tribes and other Federal agencies, the USGS collects, analyzes and interprets data on Great Lakes fishery resources and on anadromous and interjurisdictional species on the Atlantic, Pacific and Gulf Coasts. This information is critical to effective regulation of fisheries harvests.

Offshore Environmental Studies (Monitoring) – Offshore environmental studies conducted by the USGS provide environmental monitoring information to the Department's Minerals Management Service (MMS) for use in offshore oil and gas exploration development and production decision making. These data can be used to develop mitigating measures for offshore operations.

Standards and Protocols – USGS scientists are continuing to develop standards and protocols to implement many different inventory and monitoring projects. The protocols include statistical sampling that is important for tracking trends in biodiversity, effects of contaminants, ecological restoration, and many other activities.

Taxonomy, Systematics, and Museum Studies – At the National Museum of Natural History, a major repository of information important in the conservation of species, USGS scientists study variation in natural communities of animals. Curation of North American vertebrate

collections at the Smithsonian Institution provides stewardship of an important scientific database available to scientists from around the world.

Recent Accomplishments

Report on the Status and Trends of the Nation's Biological Resources – In FY 1999, USGS completed a comprehensive report on the Status and Trends of the Nation's Biological Resources. This 4-year project resulted in a two-volume report of 1,000 pages, covering terrestrial and marine biological resources; factors such as natural processes and land use that affect those resources; and regional trends in different areas of the country. This report is a major publication that synthesizes and integrates important natural resource information and makes it available to the public. It is being widely distributed to federal and state agencies, nongovernment organizations, schools, and public organizations.

Quantitative Analysis of Shorebird Monitoring Programs – In FY 1999, USGS scientists completed an analysis and reporting of data from the International Shorebird Survey to estimate the reliability of shorebird monitoring programs conducted during non-breeding periods. The report is playing a central role in development of the National Shorebird Conservation Plan.

Improvements in the North American Breeding Bird Survey (BBS) – The BBS is a long-term continental bird-monitoring program that tracks the status and trends of North American bird populations. The U.S. Fish and Wildlife Service and Partners-in-Flight use this information to make meaningful bird conservation plans and for population data on certain game birds, like band-tailed pigeons, which are not monitored effectively by other surveys. To meet the needs of these agencies the USGS has developed a BBS Internet retrieval site (http://www.mp2?pwrc.usgs/bbs/retrieval/) that allows access to BBS data and can process a wide variety of customized data requests.

Contaminants

Fish and wildlife populations are increasingly threatened and imperiled by a wide array of environmental toxins and contaminants. A growing global concern is the effect from exposures to chemical mixtures such as those commonly encountered with industrial development, mining activities, farm irrigation practices, treatment of domestic sewage, and animal feedlot operations.

A critical gap exists in our scientific knowledge concerning the response of fish and wildlife to contaminant mixtures, as well as the effects of contaminants acting in concert with disease. Resource managers in DOI and other Federal, State, and local agencies are faced with increasing fish and wildlife mortality events. The managers need timely and accurate information about the causes and magnitude of mortality and methods to reduce contaminant related impacts and prevent devastating mortalities in the fish and wildlife resources they protect and manage. The US Fish and Wildlife Service, National Park Service, Bureau of Reclamation, and Office of Surface Mining have all expressed a critical need for information on the effects of contaminant mixtures and population-level effects on fish and wildlife resources.

Contaminant research and monitoring is directed at understanding how contaminants affect organisms, populations, and ecosystems. Concurrent long-term biomonitoring is used to assess the effects of contaminants and biological agents on the Nation's biological resources, especially those under DOI stewardship. This work is also dependent on work of Water

Resources Toxics programs. Scientists from these divisions work cooperatively to incorporate biological endpoints into the NAWQA program and to use hydrologic expertise to solve water resource problems on DOI lands.

Environmental Toxicological Research – Research includes controlled laboratory and field studies and is directed at understanding environmental contaminants; describing the relative toxicities of individual and mixtures of chemicals to a variety of species; and evaluating cause-and-effect linkages between contaminant stressors and observed impact. Toxicological research involves:

- Evaluating the population-level effects on important species of fish and wildlife caused by exposure to contaminants. This research focuses on DOI trust species and DOI lands.

- Determining the physiological mechanisms through which contaminants affect critical life processes such as growth, reproduction, immunity and the stress response.

- Providing DOI agencies with technical information on the management and prevention of fish and wildlife contaminant mortalities as well as technical assistance, models and technology transfer of novel tools and approaches to mitigate their effects.

- Providing the technical information and assistance for a better understanding of how to restore contaminated and polluted DOI lands.

Biomonitoring of Environmental Status and Trends (BEST) – The BEST Program monitors, identifies, and assesses the effects of environmental contaminants on the Nation's biological resources, particularly those under the stewardship of the DOI, in order to provide scientific information to guide management actions. Long-term database information provides resource managers with comparisons of broad geographic areas, benchmarks for interpreting results of site-specific investigations, and assessments of temporal changes in exposure and affect.

Recent Accomplishments

Great Lakes Diving Ducks – USGS scientists have identified high selenium concentrations in livers of diving ducks that winter in and migrate through western Lake Erie, Lake St. Clair, and southern Lake Michigan. Selenium concentrations found in livers of over 70% of lesser scaup, bufflehead, and common goldeneye, were either elevated or were above a value considered harmful. Reproductive effects in farm mallards were observed when selenium concentrations exceeded an elevated level in livers. These results may have implications for the nationwide decline of North American lesser scaup populations, which in 1998 were at the lowest recorded levels since breeding waterfowl surveys began in 1955. These data may be used by management agencies, both State and Federal, to aid in the recovery of these species.

Western Reservoir Ecology – USGS, in partnership with the Bureau of Reclamation (BOR), has completed one year of research at western reservoirs located at Elephant Butte, NM; Angostura Unit, SD; and San Pedro River, AZ. Researchers investigated water quality concerns as a part of the Clean Water Action Plan. High concentrations of sulfides in the tailrace of the Elephant Butte Dam have adversely affected the downstream trout fishery and pose potential hazards to the Dam workers. At the Angostura Reservoir and Dam, and the San Pedro River, there are increased concerns about the quality of irrigation drainage into these

reservoirs and its potential harmful effects on fish, wildlife and human health. USGS scientists have collected field data, synthesized available literature, and are analyzing physical and biological samples for contaminants. These data and findings will be used by the management agencies in the restoration of these western reservoirs and downstream waters.

Restoration of Stream Waters Degraded by Acid Mine Drainage – Acid mine drainage (AMD) in the Appalachian coal region has degraded more than 8,000 miles of streams and has left some aquatic habitats virtually lifeless. USGS scientists have developed and received two U.S. Patents for a new process that reduces the risk and cost of restoring AMD degraded waters. Field tests conducted at the Toby Creek Mine Drainage Treatment Plan (Pennsylvania) demonstrated the ability of the process to work effectively under a wide range of operating conditions. Additional field tests are under development in cooperation with The Conservation Fund's Freshwater Institute in Pennsylvania and Maryland as part of a Cooperative Research and Development Agreement with USGS. Results will be most useful in the development of AMD restoration technology for the Appalachian coal mining region.

Biomonitoring of Environmental Status and Trends (BEST) – In FY 1999, the BEST program provided DOI bureaus with a number of products to assess contaminant effects on natural resources. A user guide for the Contaminant Assessment Process was tailored to meet the needs of the U.S. Fish and Wildlife Service and has become part of the Service's standardized process to assess contaminant threats on national wildlife refuges. Summaries of biological characteristics of birds and other species found in coastal habitat (including data on contaminant exposure and effects on these species) are accessible at www.pwrc.usgs.gov/bioeco/. Scientists and natural resource managers regularly use these data to plan assessments and interpret results from their investigations. A comprehensive database of ecotoxicological data for species in Atlantic coastal habitats is accessible at www.pwrc.usgs.gov/ceetv/. This database has been used to identify information gaps, focus biomonitoring efforts, and identify areas for mitigation and restoration. Users of these web sites are from DOI bureaus, other federal agencies, State and local governments, industry, environmental organizations and the public.

Fisheries and Aquatic Resources

Research conducted in the Fisheries and Aquatic Resources program area centers on determination of factors affecting the reproduction, survival and health of fish and other native aquatic fauna including their physiology, behavior, genetics and habitat requirements. The USGS develops and evaluates methods for restoring and managing populations and communities through culture techniques, artificial propagation, and the diagnosis and treatment of disease. Scientists determine the systematics, taxonomy and distribution of species of concern, including identification of populations and their taxonomic relationships, habitat characteristics, resource needs, and the biological integrity of multi-jurisdictional aquatic systems, including the effects and mitigation of habitat alterations on riverine species.

Fish Passage – The USGS maintains a unique environmental laboratory designed to test structures that allow fish to by-pass dams or other obstructions that limit access to spawning grounds affecting the long-term survival of migratory species. Information is developed on physiological, behavioral, and hydraulic phenomena that determine the success of artificial structures intended to allow fish to pass around river obstacles.

Coastal Fisheries – Coastal fishery studies encompass important species on all coasts. Important fishes in San Francisco Bay and small California estuaries, and in Glacier Bay are

being studied on the West coast. On the East coast, work on striped bass restoration includes improving marking methods and developing cost-effective culture techniques. Efforts are underway to better understand food sources of native fishes.

Fish Biology – The USGS fishery research program examines all phases of the life cycles of fish and their habitat requirements. The goal is to relate the research findings to management techniques in order to restore the fish populations. Research on imperiled fishes focuses on interactions with nonnative species while limnological studies examine changes in water quality associated with land-use and diversion and impoundment of streams.

Fish Genetics — Studies in fish genetics characterize variability and taxonomic status of individuals, stocks, races, and populations. Assessed information is used to help manage harvest and determine restoration strategies. Efforts underway include identifying genetic traits for restoration of Atlantic and Pacific salmon and lake trout, cataloguing genetic attributes of fish hatchery stock, and genetic identification of salmon in Alaska to improve stock management.

Fish Disease — Fish disease research focuses on development of better methods for detection of causative agents, fish species resistance to disease, the role of environmental contaminants upon the disease cycle, improved diagnosis of disease, and development of new vaccines. The results are used to understand the factors that control the distribution and transmission of fish diseases and the effects on fish restoration efforts.

Native Mussels — The USGS is a nationwide leader in research and monitoring of native freshwater mussels. Freshwater mussels are an important, but a threatened, component of aquatic ecosystems. The factors that make freshwater mussels excellent indicators of water quality also make them vulnerable to water pollution, sedimentation from upland sources, and habitat destruction. USGS research and monitoring activities identify how invasive species and environmental degradation of streams, rivers and lakes are affecting mussel populations and how remaining populations can be protected. Techniques developed by USGS biologists are being used to hold, propagate, relocate, and reintroduce native mussels, and new methods are being developed to determine their distribution and abundance.

Large Rivers — USGS research related to the unique resources and conditions found in America's large rivers, such as the Missouri, Mississippi, and Columbia, is developing vital information on fish community structure and function, habitat restoration, migratory bird habitat, hydrology and hydraulics of the rivers, degree of sediment contamination, and water quality. This information will be used by water managers to respond to increasing demands and legal mandates for high quality water with reliable and integrated scientific information.

Great Lakes — USGS scientists conduct a regional program of research to develop the knowledge and technical basis for assessing, protecting, and rehabilitating the valuable fishery resources and aquatic habitats in the Great Lakes. The research program includes studies of the biology and dynamics of important sport, food, and forage fish populations, and evaluation of habitat limitations that inhibit successful survival, reproduction, and recruitment of these populations.

Recent Accomplishments

Fish Passage at the Little Falls Dam – Scientists at the Leetown Science Center, working with the Fish and Wildlife Service, Army Corps of Engineers, and State agencies, designed a unique fish

passageway that will allow American shad and other species to pass over the Little Falls Dam on the Potomac River near Washington, D.C. The dam currently prevents fish from reaching their historic spawning grounds. The passageway, developed at the Center's Conte Anadromous Fish Research Laboratory in Turners Falls, MA, includes wedge-shaped weirs designed to slow water velocity for upstream fish migration and to be self-maintained. When construction is completed, the passageway will open a 10-mile stretch of the river for fish spawning.

Whirling disease: research advance – USGS scientists, in their ongoing efforts to assist in the control and management of Whirling Disease in salmonids, have developed a quantitative polymerase chain reaction (QPCR), a molecular technique that amplifies DNA, to enhance our understanding of the life cycle of the causative agent's development. The development of the QPCR opens new doors for in-depth studies of the parasite in the aquatic environment.

Research to determine levels of bacteria shed from fish with Bacterial Kidney Disease (BKD) – Research on BKD has been hampered by the slow growth rate of the causative agent, *Renibacterium salmoninarum,* by the lack of artificial challenge systems that mimic natural routes of infection, and by a lack of information on the levels of *R. salmoninarum* shed during infection. Scientists at the Western Fisheries Research Center (WFRC) developed reproducible waterborne and cohabitation challenge systems to infect fish and tested levels of bacteria produced during infection that resulted in transmission of the disease to other susceptible fish. Results showed that infections result from exposure to very low concentrations of the bacterium and that the progression of the disease was similar to that observed in hatcheries and nature. The levels of bacteria shed during infection were monitored over time to give scientists a better idea of the period in which the risk to other fish is greatest.

Wildlife

Research conducted in the Wildlife program area focuses on investigations of factors regulating the distribution, abundance, and condition of wildlife populations and communities including their behavior, genetics, and habitat requirements. Studies also evaluate the effects of disease on wildlife populations and communities and the prevention and management of disease in free-ranging biota.

Migratory Game Birds — USGS research on migratory game birds supports the Interior Department's stewardship responsibilities. Much of this work is in cooperation with the FWS and state fish and wildlife departments that have direct responsibility for managing populations and harvests. The USGS provides information needed to protect and enhance waterfowl and other game bird populations on national wildlife refuges waterfowl production areas, and other wildlife management units.

Non-Game Birds — USGS research focuses on environmental factors and human influences on productivity and survival in non-game species. Because of increasing urbanization, as well as agricultural and logging practices, many bird populations are threatened and degraded due to fragmenting and degrading habitats. USGS biologists investigate specific habitat requirements of songbirds, seabirds, shore birds, and eagles.

Large Mammals — Large mammals inhabiting Federal lands are a major concern of land managers, particularly when there are conflicts between populations of these animals and humans or human activities. USGS scientists conduct studies to seek a better understanding of habitat needs and management practices that will reduce conflicts between animals and humans or livestock and reduce damage to vegetation.

Arctic Studies — USGS conducts research in the Arctic to help DOI agencies in Alaska meet their resource management responsibilities.

Wildlife Disease — USGS supports a unique national program dealing with all aspects of wildlife health issues providing research and technical support to the FWS, other Federal agencies, and state fish and wildlife agencies.

Population Modeling — Computer simulation models help wildlife and land managers make difficult decisions when dealing with uncertainty such as arrival of migrants in the spring, selection of nest sites, and survival of nests and broods.

Amphibian Monitoring — USGS scientists are developing quantitative methods for assessing amphibian populations at several geographic scales across the continent. These methods are field tested by resource managers and provide techniques to readily gather information on amphibian changes at local, regional and national scales.

Recent Accomplishments

Population dynamics of white-faced ibis – USGS scientists analyzed population trends and colony dynamics of white-faced ibis breeding in the Great Basin during 1985-1997. The synthesis included all known colonies in six states and incorporated data from state agencies, several U.S. Fish and Wildlife Service Refuges, and others. Results indicate that this Species of Management Concern has nearly tripled in size since 1985. The increase is present in all parts of the range. Colony dynamics indicate the ability of this highly nomadic species to compensate for poor conditions at traditional sites by moving among colonies and rapidly colonizing newly available wetlands. This tendency has major implications for how ibis habitat can best be maintained and how ibis populations can best be monitored. The final product was published as a scientific article in the journal Colonial Waterbirds.

Migratory Bird Monitoring – During FY 1999, USGS scientists established migratory bird monitoring sites along the Colorado River corridor between Yuma, Arizona and Moab, Utah, as well as one site at Zion National Park, Utah. Forty-two individuals of six different bird species were equipped with transmitters and were tracked during spring and fall migrations throughout the Colorado River corridor to determine habitat use and availability.

Contaminant analysis of birds on the Salton Sea – Fieldwork began in April 1999 to monitor the nests of a small colony of Great blue herons (GBH) and Great egrets (GREG). These were selected for intensive nest monitoring to determine the effects of contaminants on offspring. Forty-five nests were established during this period, predominantly by GBH. Less than 10 GREG nests were established and contained eggs. Only four GREG nest survived to the point of producing hatchlings, and no GREG nest survived to fledging. Seven GBH nests remained intact and produced fledglings. The Salton Sea routinely experiences severe windstorms during the spring and summer, and the particular area of the Ibis Road
colony seems to be especially prone to severe, prolonged high wind events. These extreme winds rip apart fragile nesting structures and the nest themselves.

Brown bear populations on Kodiak Island, Alaska – The brown bear *(Ursus arctos middendorffi)* population of Kodiak Island is significant as a wildlife resource and of management concern because of increasing public. USGS undertook a study to determine the

status of bear populations in representative habitats, investigate ecological factors that influence the bear population, and evaluate interactions between bears and humans. The habitat data and information on interactions between bears and people provide guidance for education programs and commercial operators. Density and population information will provide the foundation of assessing population change and sport harvest.

Public Use and Its Effect on Florida Panthers in Big Cypress National Preserve – Big Cypress National Preserve in Florida comprises approximately one-third of the land where the endangered Florida panther *(Felis concolor coryi)* lives. As a National Preserve, deer and hog hunting are allowed. The National Park Service requested that USGS wildlife biologists evaluate the potential effects of this human activity on the behavior of panthers on the newly acquired lands in the northeast comer of the Preserve. Between 1995 -1998, USGS scientists examined these potential impacts and produced a final report in FY 1999. The study documented a minimum impact by hunting. In addition, it appears the panthers learned to use adjacent lands or in-holdings as refugia during the hunting season.

Ecosystems

Ecosystems program area studies improve knowledge about the complex interactions among the living and abiotic components of the earth's ecosystems. Such interactions include the biogeochemical processes, energy pathways, and the interchanges between and among ecosystems. An important focus is to explain why the observed heterogeneity of biological communities develops across landscapes and to understand the ecological processes involved. Investigations identify, explain, and predict the consequences of short- and long-term environmental changes. Activities include assessing ecosystem vulnerability to adverse effects of environmental change and providing information needed to adapt to and mitigate these effects. Topical areas for Ecosystems research include the ecology of wetlands, forests, and grasslands; landscape ecology; modeling ecological systems; ecosystem restoration; fire ecology; and global change.

The USGS is a leader in research and understanding of the role of land-use change and associated erosion and sedimentation processes on carbon sequestration in sediments. Carbon sequestration is the capture and storage of carbon that would otherwise be emitted to or remain in the atmosphere. Wetlands, shallow estuaries, peatlands, bottomland forests, and arctic tundra and tiaga occupy large areas and have the potential to process large quantities of carbon over short and long time scales. Land use change in the lower 49 States and Alaska is emerging as a major influence on carbon cycling and sequestration. In FY 2001 the USGS plans to refocus some of its work on climate change and wetland processes associated with carbon storage. New work will focus on field based measurements and modeling of the effects of climate and hydrologic change on carbon and nutrient cycling and carbon sequestration, and biological processes in wetlands and riparian areas. Primary focus will be in the lower Mississippi basin region.

Coastal Wetlands/Habitats — Important coastal wetlands and adjacent shallow waters have suffered significant losses this century. USGS biologists investigate coastal wetland structure and function (including Great Lakes habitats) to assess and predict the effects of human activities and environmental change and to measure the effects of management actions. Studies examine the ecological responses of coastal wetlands to stressors, including sea-level rise, carbon dioxide enrichment, and nutrient and contaminant inputs. Research into non-native species effects, the effects of physical disturbances such as canal dredging and filling, hurricanes, and floods are ongoing. Methods and standards for restoring coastal wetlands are

under development, adaptive management evaluations are being conducted, and computer ecological modeling is being conducted to emphasize future predictability and to design restoration and management tools

Outer Continental Shelf Environmental Studies — Information on long-term effects of offshore oil and gas exploration and production activities, including effects of production platforms on fish assemblages and changes to existing biological conditions in areas of potential or new production, is needed. USGS scientists collaborate with the MMS to determine the health and appraise the vulnerability of marine biological communities that could be affected by offshore oil and gas exploration and production.

Coral Reefs — Among the most diverse and biologically complex ecosystems on earth, coral reefs and associated marine habitats appear to be in worldwide decline and the causes are poorly understood. Issues of major concern include coral diseases, water quality and algal blooms, interactions with sea grass beds and mangrove communities, and coral reef fish population dynamics. USGS biologists conduct long-term, integrated research on coral reefs and related ecosystems in Florida, the Caribbean, and Hawaii.

Range and Grasslands — Studies at various scales on native grasslands and managed rangelands are conducted to evaluate range conditions, determine rare plant patterns, appraise species richness, and identify concentrations of native plant diversity. These studies provide managers with baseline information and are the basis for techniques to detect human-induced stress in natural biological communities and for developing management actions for restoring and maintaining the productivity of rangeland ecosystems.

Deserts and Arid Lands — Over the past century in the southwestern U.S., an invasion of shrubs such as creosote bush and mesquite have impacted large expanses of semi-arid grasslands that naturally support a complex mix of plant and animal communities. Livestock and native animal grazing, recreational activities, agricultural use, and other management practices have also affected these communities so land managers need information to protect and restore productive ecosystems. Studies are being conducted into effects such as decreased nutritional content of plants, lower diversity of native species or decreased productivity, decreased water availability, diminished soil microbial populations, and accelerated rates of soil surface erosion.

Prairie Wetlands — The northern prairie pothole region in the Great Plains is the principal breeding ground for waterfowl and other waterbirds and serves as the key staging area for migratory sandhill cranes, shorebirds, and arctic and subarctic-nesting waterfowl. USGS scientists are evaluating the current status of prairie wetland ecosystems, investigating factors influencing wetland use by birds, amphibians, and aquatic macroinvertebrates, and quantifying characteristics of restored wetlands. Research on landscape patterns and the interactions of wetland biota with hydrology, geochemistry, and sediments is focused at basin and landscape scales because prairie pothole wetlands are in fragmented grassland habitats.

Forested Wetlands — Forested wetlands are the most rapidly declining wetland type in North America. USGS scientists are providing technical information needed to manage forested wetlands and their flora and fauna, including both economically valuable species and species at risk. Research focuses on multiple aspects of wetland regeneration and restoration in the Southeastern United States including site selection and preparation; seeds, seedlings, and biodiversity enhancements; planting and management procedures, and monitoring. Scientists

are seeking to quantify the role forested wetlands play in nutrient cycling, the retention of nutrients, and the regulation of nutrients entering waterways.

Global Change — Biologists in the U.S. Global Change Research Program do research in six topical areas to address global climate change effects on: coastal and interior wetlands, western mountains, arid lands, sensitive species and island ecosystems, bird/habitat interactions, and watershed biogeochemistry. Specific projects include the effects of climate change on Great Lakes wetlands, the response of desert vegetation to climate change in the southwest, sea-level rise and impacts on Atlantic Coast migratory birds, and the effects of climate change on carbon and nitrogen biogeochemistry in national parks. Research goals are to: (1) determine sensitivity and response of ecosystems to climate and environmental factors at local, landscape, and regional levels; (2) predict future global change impacts on the structure, function, and viability of natural systems; and (3) assess implications of change for resource management.

Recent Accomplishments

Wood Recruitment and Redistribution in a Coast Range Stream – Trees and large pieces of wood are critical to the structure and function of coastal streams because they affect channel shape, routing and storage of water and sediment, and provide habitat for aquatic and terrestrial organisms. USGS studies demonstrated that processes on local hill slopes and in riparian areas contribute more wood to the channel than do fluvial processes. In smaller streams that drain steep hill slopes, slope instability is the major factor in large wood recruitment while in slightly larger, moderate gradient streams with wider valley floors, wind throw is the primary recruitment process for large woody debris. The results will guide forest management practices.

Wind Erosion of Desert Landscapes – USGS researchers used a portable wind tunnel to measure susceptibility to wind erosion and sediment production in undisturbed and vehicle-disturbed soils in the Chihuahuan, Mojave and Colorado Plateau deserts. Undisturbed desert soil surfaces, protected from wind erosion by surface crusts, produced little sediment but soils experimentally disturbed with vehicles, horses and foot traffic produced up to 36 times the sediment loss of undisturbed surfaces at wind velocities below commonly-occurring wind speeds. This potentially leads to reductions in soil flora that contribute to desert soil stability and to reduced fertility, important factors in desert management and restoration activities.

Fire Effects in California Brushland Ecosystems – USGS scientists have determined that fire suppression in southern and central coastal California shrublands has not altered the frequency and intensity of large wildfires or the natural fire regime. In contrast to coniferous forests, no evidence was found to support the notion that suppression has reduced acreage burned or caused increased fuel accumulation leading to greater fire intensities. Large fires in these shrublands usually occur during Santa Ana winds and burn through all fuel age classes. Prescribed burning to achieve large-scale age class modification are not likely to be effective in altering fire behavior under Santa Ana conditions. Urban sprawl, not fire suppression, may be most responsible for loss of property and lives from brushland fires and resource managers may reexamine prescribed burning programs in California shrublands.

Application of Science Information to Management

The scientific knowledge gained by USGS and other researchers is often made useful to natural resource managers through development of decision support systems that harness vast amounts of scientific data and present it to decision makers in an understandable form. The

"Applications" program works in close collaboration with natural resources agencies to develop the scientific tools that combine advanced technologies with scientific information to assist land managers in making wise management decisions. Development of models and decision support tools assists decision making in such areas as land-use planning, land and water management, timber harvest, wetland management, fish and wildlife management, endangered species policies, invasive species prevention and control, urban development, and other areas involving human interactions with biological resources. These tools incorporate the best available economic, social, and ecological science information to offer alternative ways to balance social and economic needs with natural resource management and conservation. Examples of these efforts include the Upper Mississippi River Decision Support System, VegSpec-Revegetation Tool, Socioeconomic Evaluation of the Conservation Reserve Program, and the Across Trophic Level System Simulation System for decision making in South Florida.

Predictive Population Modeling — Through development of predictive population models, this program assists resource managers in making difficult decisions by reducing the uncertainty associated with population responses to habitat and environmental change. In essence, these models allow managers to project the likely outcome of various management alternatives on populations of plants and animals.

Science for Decision Support Systems — Land and other natural resource managers require strong scientific, social, and economic information to make justifiable management decisions. However, the gap between quality information and management decision making is often pronounced. Decision support systems are computer-based tools that bridge that gap by bringing the best scientific and human dimensions information to bear on specific natural resource issues. This program develops and advances the science associated with decision support systems, thereby ensuring that results from scientific research are directly funneled back into the decision making process of natural resources agencies. This program will be expanded in FY 2001 (see program change section for more information).

State and Tribal Conservation Management — Projects promoted through State partnerships between State and Tribal institutions and USGS field units address high priority conservation and management issues. Projects focus on providing scientific information needed to develop habitat and ecosystem restoration plans, and on enhancing the accessibility of scientific data and information products to State and Tribal land managers.

Adaptive Management — As more and more scientific data accumulate, and natural resource managers learn from their previous management actions, there needs to be a process of integrating that knowledge into future decision making. Adaptive management provides the conceptual foundation upon which future management issues can be successfully addressed. It is a process of evaluating a management problem, determining project objectives, implementing a remedial strategy, monitoring the outcome, and then revising the strategy, if necessary, to achieve stated objectives. This program area forms the foundation for a new era of partnerships, investigation, and management between the science arm of private and public entities and that arm responsible for management and conservation of the Nation's natural resources. Its aim is to close the gap between scientific knowledge and application of that knowledge through strong, on-the-ground collaboration between scientists and state, federal, and private natural resource managers.

Human Dimensions and Socioeconomics — Natural resources management requires a firm understanding of biological, as well as economic and social, issues and processes. Interaction between human communities and their natural surroundings through consumptive and non-

consumptive activities can introduce various changes to ecosystems. Human dimensions studies are used to better understand those human-induced changes, determine the environmental conditions desired by local communities and users of natural resources, and develop information that assists decision-makers in sustaining or restoring healthy ecosystems.

Pacific Northwest Forest Plan — The Pacific Northwest Forest Plan calls for major changes in the management of Pacific Northwest forests on Federal lands to ensure that species associated with old-growth and riparian areas have suitable habitat throughout their ranges. USGS research is identifying the essential habitats and specific life history requirements of sensitive species required to implement the Plan.

Recent Accomplishments

I**ntegrated teams of scientists used novel approaches to provide management alternatives for restoration and conservation of aquatic habitats and wetland ecosystems –** New decision support systems and predictive models were developed, including a tool that allows biologists in Louisiana's Jean Lafitte National and Historical Park and Preserve to predict the outcome of water management alternatives on the health of forested wetlands. Along the Lower Missouri River, application of a new technology (airborne topographic mapping) is providing a new look at the underwater environment, which will offer managers of the Big Muddy National Wildlife Refuge more informed alternatives for restoring migratory bird and fish habitats that were lost during the severe flooding of the mid-1990s. In the upper reaches of the Missouri River, a decision support system was built for the Bureau of Reclamation that forecasts the effects of various reservoir operations on recreational activity, fish populations, riparian tree regeneration, power production, and other environmental, economic, and social considerations. In smaller watersheds, such as that containing Redwood National and State parks in California, scientists continued to refine models that will allow prediction of the impact of erosion and sedimentation from timber harvesting on the integrity of downstream watercourses and riparian habitats.

USGS scientists made major strides in developing and refining management tools and techniques that bolster the probability of successful recovery of high risk species – In response to the widespread concern over the loss of native mussels, biologists worked with the Pennsylvania Department of Transportation to evaluate a means of translocating individual mussels away from bridge and road construction sites, thereby mitigating impacts to those populations. This technique may have broad application in other river systems that have suffered severe declines in mussel populations. In high elevation habitats, predictive models and computer simulations were developed that provide the National Park Service a means of assessing the most effective ways to restore small, isolated populations of bighorn sheep throughout the western United States. In the low elevation Mojave Desert, development of predictive vegetation models and detailed synthesis of a diverse set of scientific information are providing federal, state, and tribal land managers guidance for conservation of endangered and high risk species, such as the desert tortoise.

Endangered and At-Risk Species

Reversing the rapid loss of biological diversity remains the greatest challenge to natural resource managers. Reasons for species' decline include habitat loss from development, agriculture, road building, reservoirs, and mining operations; habitat degradation from fire suppression, livestock grazing, damming and other changes in the amount and quality of water,

and invasions of invasive species; and health effects such as disease and contaminants. Restoring declining populations thus depends on an integrated program of research to develop critical information on the biology of individual species and the ecological relationships between those species and their habitats. Through improved data collection and analysis focused on linking physical, chemical and biological factors with others contributing to alterations in species composition and health, the USGS is providing land and resource managers with additional tools for addressing these issues.

Endangered and At Risk Species research focuses on determining the status and trends of rare species; detecting the point at which species fall into the status of being at risk; identifying factors responsible for the decline of threatened and endangered species; and assisting in the development of management plans and methods to restore depleted populations and to prevent further declines. Most USGS endangered species research supports recovery of species already having legal status under the Endangered Species Act of 1973, as amended. To help managers achieve the goals of recovery plans, USGS scientists investigate the life requirements of listed species and factors limiting their populations. Better knowledge of both requirements and limitations is needed for managers to act effectively to promote restoration of populations.

Endangered Species — USGS endangered species research provides biological information needed to restore currently listed populations, to support de-listing wherever possible, or to preclude future listings by clarifying species' status or suggesting timely preventative actions. Ongoing research provides Federal, State, and private-sector managers more effective tools to restore populations. The key to protecting both species and preventing the listing of additional species occupying the same habitats is habitat conservation planning. In partnership with DOI resource management bureaus and with State and local governments, USGS scientists are providing the kinds of sophisticated technical knowledge required to develop and implement effective habitat conservation plans.

Species at Risk — USGS scientists are also involved in efforts to conserve species before they become listed, thereby avoiding associated constraints and conflicts. Species at Risk projects lead to conservation options and actions that reduce the need for listing species as threatened or endangered. Projects focus on species for which there is concern over possible endangerment, but for which either viable option still exists for long-term protection or additional field evidence is needed to assess the risk. Projects involving population viability analyses and investigations of factors causing the decline of species generate new information to support species protection and restoration efforts.

Recent Accomplishments

Southern California Habitat Conservation Plan – In support of the Coastal Sage Scrub Natural Community Conservation Planning (NCCP) Program in Southern California, USGS scientists at the Western Ecological Research Center are conducting an analysis of existing monitoring efforts and developing a comprehensive ecological monitoring strategy. This effort will help to determine if the ecological system within the 6,000 square mile NCCP planning area is functioning effectively and is self-sustaining. While the research work is still ongoing, major accomplishments include the development of necessary conceptual models for the program at a workshop involving our partner agencies, the expansion of the herpetofaunal monitoring program to include six new sites and initiation of amphibian monitoring sites within the

Cleveland National Forest. Products to date include four reports to client agencies, two book chapters, and a presentation. Details follow:

The clients are: U.S. Fish and Wildlife Service
National Park Service
California State Parks
California Department of Fish and Game
The Nature Conservancy
U.S. Marine Corps

Reports: Neotropical migratory bird monitoring study at Marine Corps Base, Camp Pendleton, CA. Fourth Annual Progress Report. Prepared for the U.S. Marine Corps, Environmental and Natural Resources Office, Camp Pendleton, CA, 45 pp.

Recovery plan for the least Bell's vireo and its riparian habitat (draft). Prepared for the U.S. Fish and Wildlife Service, Carlsbad, CA Field Office.

Pilgrim Creek Restoration Project: Bird Community and Vegetation Structure. Prepared for the CA Dept. of Transportation, District 11, 34 pp.

Radio-telemetry study of Bufo californicus, arroyo toad movement patterns and habitat preferences. Contract Report for the California Department of Transportation Southern Biology Pool. 66 pp.

Book Chapters: Case, T.J. and R.N. Fisher. In press. Measuring and Predicting Species Presence: Coastal Sage Scrub Case Study. (for Spatial Modeling Book--product of NCEAS).

Ver Hoef, J.M. Cressie, N., Fisher, R.N., and T. J. Case. In press. Uncertainty and spatial linear models in ecology. (for Spatial Modeling Book--product of NCEAS).

Fisher, R.N. and T.J. Case. In press. Distribution of the herpetofauna of southern California with reference to elevation effects. For symposium volume: 2nd Interface between ecology and land development in California.

Presentation: Research support for urban-wildland planning in Southern California (poster).

Effects of Roads on Desert Tortoise Populations in the Mojave and Colorado Deserts of California – Department of the Interior agencies that manage desert tortoise critical habitat have increasingly more complex questions about effects of roads on tortoise populations—by traffic volume, by effects of potential toxicants and by invasion of alien plants that alter composition of vegetation. USGS geologists and biologists have retrospectively analyzed the effects of roads on distribution of desert tortoises within 1.6 km of the road edge and evaluated the impacts by size and gender. Results will help to determine which roads should have tortoise-proof fencing and whether populations living immediately adjacent to roads are deleteriously affected by toxicants. Alien plant information will be used to develop mitigation measures to reduce invasions via roads. DOI land managers will use these findings as they prepare land-use plans for the Mojave and Colorado deserts.

Restoration of Imperiled Fishes in Southwest Arid Ecosystems – USGS scientists at the Western Fisheries Research Center have developed a quantitative assay for detection of heat-shock proteins that can be used as biomarkers of thermal stress in fish. The assay is being tested in the desert Southwest to assess exposure of fish to thermal stress, a condition to which they may be chronically exposed when water flows are low, as part of a decision support system for use by FWS, NPS, BLM, and State resource agencies for management of desert fishes. This technology has been selected for a patent application by DOI.

Invasive Species

Non-indigenous invasive plants, animals, and disease organisms cause increasing harm to native species and significant economic losses by reducing productivity and foreclosing opportunities for beneficial uses of forests, croplands, rangelands, and aquatic resources. In recent years, many species introduced decades ago have begun to spread rapidly in U.S. ecosystems and pose increasing threats to lands and waters managed by the Department of the Interior. USGS research fills an important niche in Federal efforts to combat invasive species in natural and semi-natural areas through early detection and assessment of newly established invaders, monitoring of invading populations, improving understanding of the ecology of invaders and factors in the resistance of habitats to invasion, development and testing of alternative management and control approaches, and facilitating the availability and integration of information on invasive species. USGS research on invasive species includes all significant groups of invasive organisms in terrestrial and aquatic ecosystems. However, available resources have enabled USGS to intensively study only a small number of the rapidly spreading invaders identified as priority concerns on DOI lands and waters.

A new focus of work in FY 2001 relates to the growing threats from invasive plants, animals, and pathogens to ecosystems, native species, resource-based economic activities, and public recreation. These threats have emerged as a major management issue affecting all regions of the U.S. USGS plays a major role in Federal efforts to combat invasive species under the new Executive Order on Invasive Species. New work will focus on supporting research in ecosystems and ecoregions such as Hawaii, California, and eastern waterways on the ecology of invaders and factors in the resistance of habitats to invasion, modeling to predict probabilities and locations of future invasions, and development of integrated approaches for control of invasive species.

Hawaiian Invaders — Hawaii's flora and fauna, which evolved in a high degree of isolation, are unusually susceptible to selective pressures from invasive species. Hawaii has the largest proportion of non-indigenous species of any state. Its ecosystems are especially vulnerable to the introduction and spread of invasive species due to increasing human travel and trade. USGS research focuses on the ecology and control of highly invasive plants (e.g., miconia, faya tree, strawberry guava, Kahili ginger), including exploration and testing for biological control agents; animals (e.g., Argentine ant, yellow jackets, brown tree snake on Guam); and wildlife disease organisms, and methods for reducing the impacts of invasive species on the region's unique native flora and fauna.

Weeds in the West — The USGS is conducting a multi-scale, integrative program for mapping infestations and accurately monitoring the spread of invasive plants (i.e., weeds) in western forests and rangelands, improving methods for predicting areas most vulnerable to invasions, assessing the effects of management practices and natural disturbances on invasions, and providing improved methods for reducing the impacts of invasive weeds on native species and for restoring public range lands affected by weed invasions.

Invasives in the East — The USGS conducts research on invasive species that are threatening ecosystems and on native species in the eastern states. These efforts include surveys of non-indigenous species in eastern parks and wildlife refuges, studies of pathways for establishment and spread of invasive species, research on the impacts of invasive species and factors in invasions (e.g., management history, natural and human caused disturbances), and

development of methods to control or eliminate invasive species and promote healthy native communities that are resistant to invasion.

Great Lakes Invaders — USGS research supports cooperative efforts in the Great Lakes region to prevent and control the spread of invasive fish, such as the round goby and sea lamprey, reduce the pervasive impacts of zebra mussels on U.S. waterways, and manage or mitigate the adverse ecological and economic impacts of the invaders.

Recent Accomplishments

Control Barriers for Invasive Fish – Scientists at the USGS Great Lakes Science Center helped design, and oversaw construction of a new sea lamprey (Petromyzon marinus) barrier on the Ocqueoc River, Michigan. The barrier, which combines two proven technologies of a low-head, and a pulsed electrical barrier, will more consistently block sea lamprey spawning migrations in Great Lakes tributaries. Under normal flow conditions, the low-head barrier blocks spawning-phase sea lampreys, but does not block jumping fishes such as migratory rainbow trout (Oncorhynchus mykiss). During spring floods, which generally last less than 3 days but are up to 8 ft deep on the Ocqueoc River, the electrical barrier automatically activates to block all fish passage. Traps incorporated in the new barrier caught about 70% of the sea lamprey spawning migration in 1999, compared to an average catch of about 50% in prior years. The new design will allow the Great Lakes Fishery Commission, in cooperation with the US Fish and Wildlife Service, Canadian Department of Fisheries and Oceans, the eight Great Lakes States, and the Province of Ontario, to expand its sea lamprey barrier program to streams where flooding makes low-head barriers ineffective. Expansion of the barrier program will reduce the number of stream miles treated with chemical lampricides, the only other currently effective method of sea lamprey control.

Techniques for the Control of the Noxious Pepperweed – Non-native vegetation threatens many areas in the U.S., both economically and ecologically. Perennial pepperweed (Lepidium latifolium) is an invasive invader throughout western North America that is listed as a noxious weed in 10 states, mostly in the western U.S. The USGS conducted studies at the Malheur National Wildlife Refuge, where this weed has invaded about 10% of meadow habitats and displaced native vegetation. The studies were conducted to determine the most effective and least environmentally harmful treatment to control this weed and to restore native vegetation using integrated pest management techniques. Two herbicides were found to be the most effective treatment, with greater than 90% reduction in pepperweed stems following application. Sheep grazing also was effective and almost completely restricted flower production. Managers at the refuge have taken recommendations from our research and begun applying them in order to control this nonnative weed.

The Impact of Aquatic Mammal Invasions: Nutria – Based on fieldwork in Louisiana, USGS developed a model describing the effects of nutria has on loss of coastal marshes. Analysis of the model indicates that nutria populations remain healthy until their foraging has nearly or completely destroyed the marsh habitat. The research showed that damage from nutria could only be assessed prior to the winter aging of marsh vegetation, and that nutria populations should be controlled in the fall. In a separate study, USGS scientists assisted the State of Louisiana in completing a coastwide survey of nutria damage that documented roughly 100,000 acres damaged by nutria. If damaged areas are not rapidly revegetated, they will convert to open water and will be very difficult and costly to restore.

Impacts of Introduced Avian Diseases on Native Honeycreepers – The introduction to Hawaii of avian pox and avian malaria, along with Culex mosquitoes which spread these diseases, has had a heavy impact on native forest bird communities. USGS scientists have taken a leading role in evaluating the effects of these diseases on highly susceptible Hawaiian honeycreepers, one of the most unique and diverse groups of native Hawaiian birds. USGS researchers have developed new diagnostic tools for detecting the diseases, conducted surveys to determine the extent of disease and vector distribution, and tested habitat management strategies for controlling mosquito populations. Ongoing investigations focus on achieving a better understanding of disease and vector ecology, and on the natural evolution of disease resistance in some honeycreeper species.

New Pesticide Application Shows Promise for Reducing Insect Threat to Native Pollinators and Endangered Plants in Hawaii – USGS research at Haleakala National Park continued to refine the use of a strategy for preventing the spread of the invasive and ecosystem-modifying Argentine ant, using aerial application of hydramethylnon (an insect growth-regulator) in a protein bait to the expanding margins of the ant's range. The ant, which has the potential to eliminate native pollinators of the threatened Haleakala silversword, covers 5% of the Park, but has the potential to occupy 50%. Progress during the year included identifying a promising remedy for weaknesses in the current application method.

USGS Completes National Book on Nonindigenous Fishes – In FY 1999, USGS completed a new book that provides detailed information on more than 500 non-native fish species, including methods of introduction, ecological and economic impacts, range maps and identification aids. It represents the state of current knowledge of nonindigenous fishes, and fills a large void by consolidating previously scattered information.